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Memo

Date: *July 24, 2015*

To: *RSC, D. Beavis, C. Schaefer & P. Sullivan*

From: *J. Alessi*

Subject: *Summary of Fault Study 242 (Deuterium beam from EBIS)*

Beam conditions:

Beam energy 2 MeV/amu
Accelerated charge/pulse = 10 nanocoulombs (6.25e10 D+ ions/pulse)
Repetition rate = 0.48 Hz (2 pulses per 4.2 s supercycle)
Average current = 4.8 nA

Based on measurements taken at the Tandem Van de Graaff for 2 MeV/amu deuterons, **expected levels for the present intensity would be the following**:

Material	**30 cm, 0 degrees (mRem/hr)**	**30 cm, 90 degrees (mRem/hr)**
Tantalum	0.75	0.6
Copper	6.5	4.4
Stainless steel	15	9
Aluminum (none present)	186	111

Note: These levels have included a correction factor of ~6 to Chipmunk values, as per the EBIS USI document.

Measured levels in the fault study, and primary materials, are shown in the following tables (measurements were taken downstream of the loss, but couldn't be taken at 0 degrees).

Normal stopping points (beamstop, diagnostics in the beamline)

Device	1010 (mRem/hr)	E600 (n's, mRem/hr)	Material
Beamstop	< 0.1	0	Tungsten
Faraday cup 47	0.1	0.07	Tantalum
Fast Faraday cup	0.05	0.23	(some Cu?)
Pepperpot screen	0.1	0.1	CsI crystal
Pepperpot mask2	0.9	0.86	Copper
Pepperpot mask1	0.6	0.53	Copper

The trend in measured levels vs. material was as expected, but the absolute levels were lower than expected by ~ a factor of 5-10. However, the table above does not include the factor of six discussed in the EBIS pre-injector USI, dated Sept. 30, 2009 and included in the first table.

Under normal operating conditions with D, the entire line was surveyed up to the final beamstop, and all levels were <0.1.

Fault conditions (intentionally trying to create losses in SS, Cu, vacuum valves, etc.)

Loss location	1010 (mRem/hr)	E600 (n's, mRem/hr)	Material
Beampipe	1.2	1.35	Stainless steel
Buncher cavity	2.5	3.4	Copper
Linac cavity	0	0	Copper?
Vacuum valve	1.7	0.75	SS
Vacuum valve	0.7	0.73	SS
Beampipe	3.8	*	SS

* Reading not taken at 30 cm. Neutron reading at 2" was 9.9 mRem/hr.

These were attempts to create worst-case losses. For the linac, it was not possible to create a loss that produced measureable radiation levels (for a wide range of beam loss conditions). The highest levels were obtained by steering the beam hard (steerer at its maximum) into the stainless beampipe.

When running D for RHIC, there will be 8 pulses per supercycle (4 times the rate used in this study). Also, the transmission from EBIS to the end of the line should improve by a factor of 2-3 over that achieved in a very short time for this study. Therefore, an increase in current by a factor of 12 over the present study could be expected.

Assuming this factor of 12 increase, the highest levels under non-fault conditions would be 10 mRem/hour (pepperpot emittance measurement). However, all the intercepting diagnostics in this part of the beamline are very rarely used (non-intercepting current transformers are the primary diagnostic), so if necessary all the intercepting diagnostics could be disabled during deuteron running. If that were done, the highest levels under normal operation would only come from beam hitting the beamstop, which was very small.

Under fault conditions, levels of 10-40 mRem/hour might be expected.